Nov. 18, 1952 G. D. ANGLE 2,618,253

RADIAL ENGINE

Filed June 13, 1947 2 SHEETS--SHEET 1

Fig. 1.

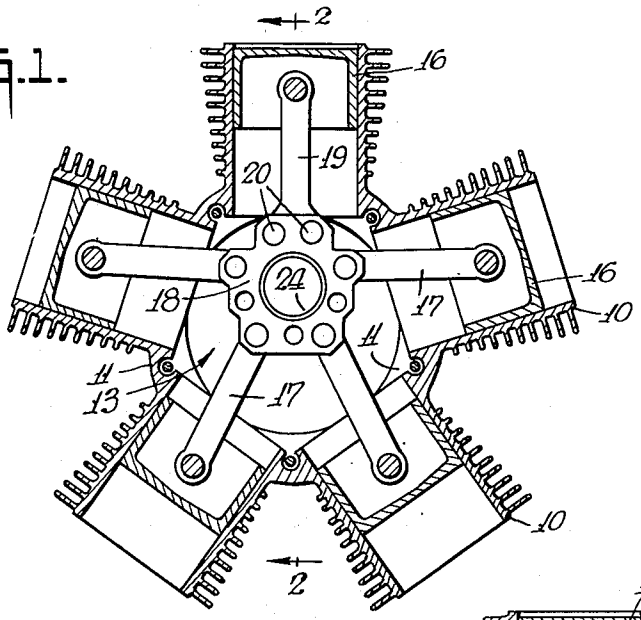


Fig. 2.

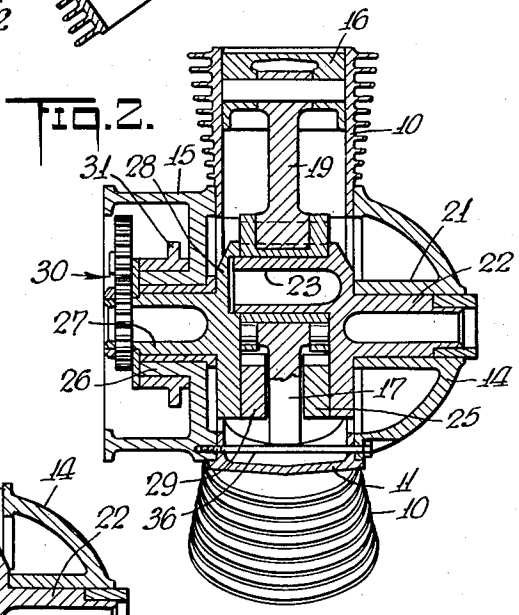
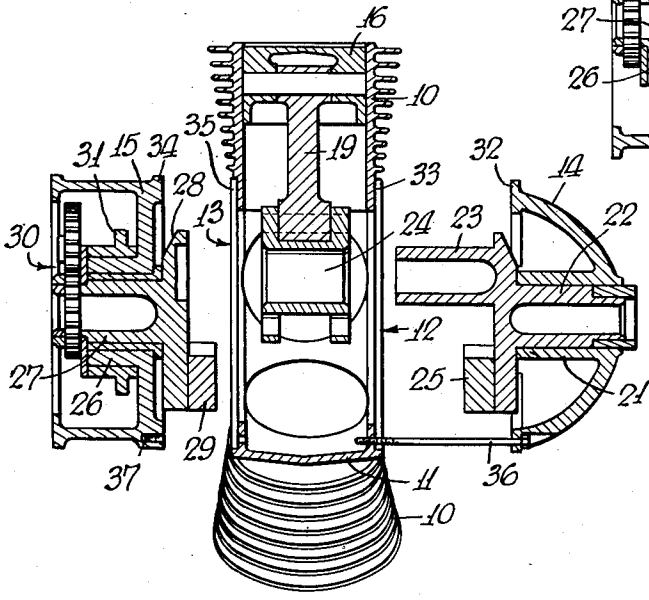


Fig. 3.



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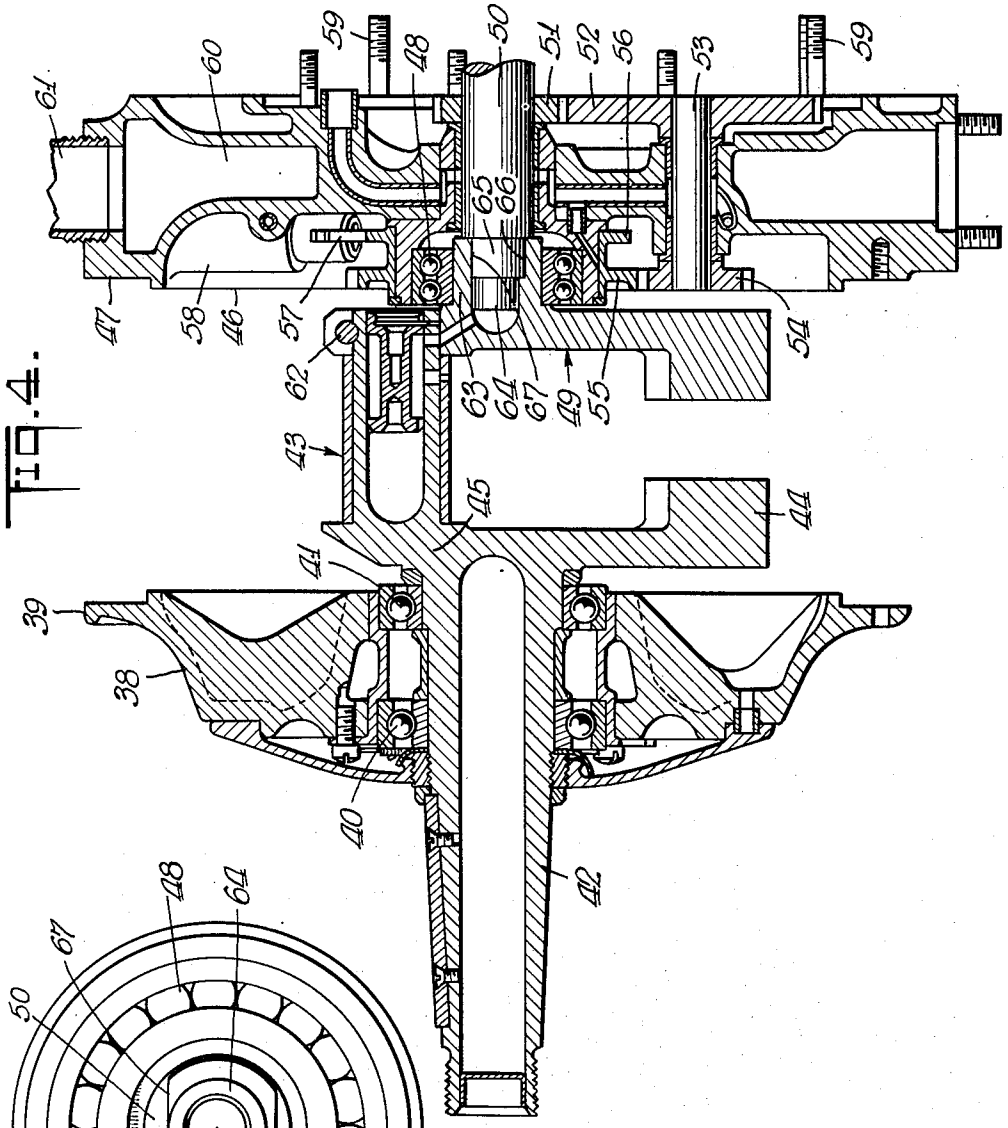


Fig. 4.

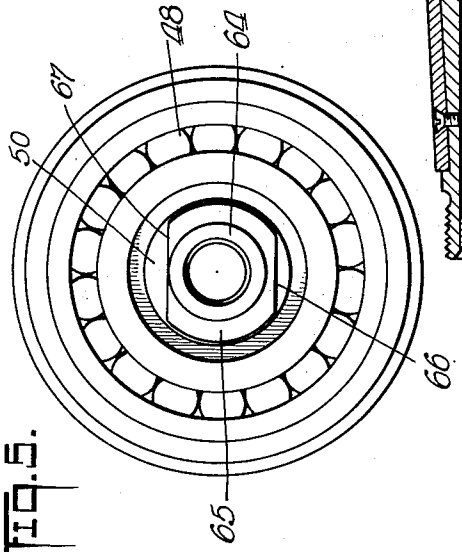


Fig. 5.

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RADIAL ENGINE

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5 Claims. (Cl. 123—195)

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My invention relates to reciprocating engines, and in particular to radial internal-combustion engines as employed in aircraft.

A primary object of the invention is to provide a simple radial-engine construction that will permit improved methods of assembly.

Another object is to provide an improved engine construction that may be fabricated at a reduced cost and that will be inexpensive to maintain.

A further object is to provide a radial-engine construction that will permit the assembly of all pistons and of their linkages to a central cluster or so-called big-end, without and before introduction of the crankshaft.

Other objects and various further features of the invention will be pointed out or will occur to those skilled in the art from a reading of the following specification in conjunction with the drawings included herewith. In said drawings:

Fig. 1 is a simplified sectional view of parts of a radial engine incorporating features of the invention, the section being taken in the plane of the cylinder axes;

Fig. 2 is another view of the engine of Fig. 1, taken substantially in the plane 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 2, but with certain assemblies separated to illustrate features of the invention;

Fig. 4 is a vertical sectional view, in considerably greater detail, of parts of a radial engine illustrative of a preferred embodiment of the invention; and

Fig. 5 is an enlarged end view of a part of the arrangement of Fig. 4, shown prior to its assembly with another part.

Up to the present time, at least three distinct methods have been employed for the arrangement and assembly of the major components of radial engines, and it is believed that a better understanding of the invention may be had after a brief review of these three methods.

According to the first, and perhaps the oldest, method of arranging the parts of a radial engine, a one-piece crankshaft was inserted through an opening in one end of the crankcase; the connecting rods (usually of the articulated type) were then assembled on the crankpin, the big-end of the master rod being made in two pieces, for purposes of assembly. After the master rod, together with the various link or auxiliary rods, had been attached, the next step was usually to install the end covers or plates which carried the main journal bearings. The upper ends of the various connecting rods could be

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made to protrude through the respective openings for the cylinders on the outer rim of the crankcase to enable the assembly of the pistons. The removable cylinders were then slipped over the pistons and bolted down upon the pads provided for their flanges on the crankcase. In brief, this method involved an assembly of each major unit during final assembly.

The second method, which has been adopted by a number of prominent manufacturers for the past several years, differed from the first mainly in that the crankshaft was made in two pieces, while the master connecting rod was made with a solid-ring big-end. In large engines this proved to be better than the first method for the reason that the solid-ring big-end of the master rod provided better bearing conditions on the whole and occupied less space, particularly from the point of view of clearance within the crankcase. To facilitate the use of this construction, the main crankcase is made in two sections joined in the plane of the cylinders, with each section carrying a bearing for the assembled crankshaft. For an accurate fitting of cylinders to the crankcase, this second method required fastening the two pieces together during machining. Aside from the problems of making the crankcase in two pieces, this method offered certain advantages as compared with the first general arrangement described.

The third method forms the subject of my Patent 1,670,294, issued May 28, 1928. According to this third method of construction, all connecting rods could be assembled to the crankshaft prior to incorporation in the crankcase. The construction thus permitted a simplification of the process of assembling a radial engine by permitting the construction of sub-assemblies.

Broadly speaking, the present invention contemplates further simplification of radial-engine assembly processes by calling for a first sub-assembly including an open-ended crankcase with cylinders, pistons, connecting rods, and the central cluster; for a second sub-assembly including an end plate to fit an end of the crankcase and to carry a first crankcase member; and for a third sub-assembly including a second end plate to cover the other end of the crankcase, and to carry bearing means for another crankshaft member. Both crankshaft members cooperate with themselves and with the cluster to form in effect a single crankshaft linked to the cluster. The three sub-assemblies may be readily fastened to each other to complete assembly of substantially the entire engine.

In the preferred specific embodiment to be described, the principal power output from the engine is transmitted via the first crankshaft member which includes a crankpin or offset bearing portion slidably receivable in the cluster. The second crankshaft member includes an offset arm which is attached to the offset end of the first crankshaft member after the latter has been inserted in the cluster, that is, after the first and second-mentioned sub-assemblies have been put together. The second crankshaft member includes a main-bearing portion which is slidably receivable in the bearing of the third sub-assembly, so that the engine is substantially completely assembled when the third sub-assembly is fitted to the first two.

Referring to Figs. 1, 2, and 3 of the drawings, my invention is shown in application to a five-cylinder radial engine having five cylinders **10** integrally formed with a crankcase **11**. The crankcase **11** is preferably annular in shape so as to provide relatively wide generally circular openings **12** and **13** at each end. It will be understood that, if desired, the crankcase may be formed as a single annular piece without the cylinders attached, and that the cylinders may be thereafter fitted upon pads suitably machined on the annular crankcase.

The crankcase may be completed by attachment of two end-plate members **14–15**, which close off the openings **12** and **13** in the crankcase and which each support parts forming separate sub-assemblies.

As indicated above, my invention is characterized by essentially three sub-assemblies. The first of these, namely, that built around the crankcase **11**, preferably comprises pistons **16** within their respective cylinders **10**, all pistons **16** being linked by means of suitable connecting rods **17** to a big-end or cluster **18**. If desired, the cluster may be a solid-ring big-end integrally formed with the master connecting rod **19**, or it may be pinned thereto as at **20**; alternatively, a split big-end construction may be employed. Also, if desired, this first or crankcase assembly may include cylinder heads complete with valve-rocker arms, and other parts attached to each of the cylinders **10**. These latter parts are not shown in the drawings, but it will be clear that they may be part of the first sub-assembly.

A second sub-assembly is preferably built around the end plate **14**. This second sub-assembly is characterized principally by a generally centrally located bearing portion **21** providing main-bearing support for a first crankshaft member **22**. The crankshaft member **22** may include offset bearing or crankpin means **23** for slidably fitting within the central bore **24** of the big-end or cluster **18**; it may also be formed with a counterweighted portion **25**, to permit a balancing of the fully assembled engine. The second sub-assembly preferably is the one through which principal engine output is transmitted; if adapted to the propulsion of an aircraft, the crankshaft may be suitably coupled (by means not shown) to the airscrew or propeller.

A third and last sub-assembly is preferably built around the end plate **15**. This third sub-assembly is also characterized principally by a bearing portion **26** providing main-bearing support for another or second crankshaft member **27**. The crankshaft member **27** may include an offset arm **28** for cooperation with the offset-bearing portion **23** of the first crankshaft member **22**, as well as a counterweight element **29**.

The third sub-assembly preferably supports suitable power take-off mechanisms for valve-timing and for other functions. In the form shown, reduction gears **30**, a valve-timing cam **31**, and cam-followers or other actuators (not shown) may all be separately built into this third sub-assembly.

For the arrangement described, a substantially complete radial engine may be formed by the concurrent or parallel construction of the three sub-assemblies—namely, the central or crankcase assembly, the front-end assembly, and the back-end assembly. Final assembly may be accomplished by slidably introducing the crankpin portion **23** in the center bore **24** of the cluster **18** until the lip or flange **32** of the end-plate member **14** fits snugly to the crankcase and cylinder sub-assembly, as in the recessed of counterbored portion **33**. When these two sub-assemblies have been fitted together in this manner, the crankpin portion **23** preferably extends sufficiently for endwise engagement with the crank-arm **28** of the second crankshaft member **27**. After inserting or otherwise associating the crank **28** with the crankpin **23**, the third sub-assembly may be fitted to the other or back end of the crankcase sub-assembly, as by homing a flange portion **34** of the end plate **15** within a recessed or counterbored portion **35** on the crankcase **11**. Suitable securing means may be provided for positively locking the three sub-assemblies together in the manner described; in the form shown, I employ longitudinally extending bolt means **36** pinning flange **32** into the recess **33**, extending across the crankcase through spaces between cylinders, and fastened ultimately in suitable tapped portions **37** in the flange **34** of the end-plate means **15**.

Referring now to Figs. 4 and 5, I show a preferred application of the principles discussed generally above to a specific radial engine. In Fig. 4 the central sub-assembly (comprising the generally annular crankcase) cylinders, pistons, and linkages have been omitted to illustrate more clearly the arrangement of bearings and the relationship of the crankshaft parts. The arrangement of Fig. 4 is, therefore, only for the purpose of illustrating the cooperation between two of the intended three sub-assemblies. The first of these two sub-assemblies constitutes the front end of the finished engine and is built around a front-end plate **38** suitably formed, as with a circumferentially extending flange **39**, for secure and tight-fitting engagement with one side of the central or crankcase assembly. The front plate **38** may support anti-friction bearing means **40—41** for free journalling of the main drive shaft **42**, which is shown formed as a part of a first crankshaft member. This first crankshaft member, like the first crankshaft member of Figs. 2 and 3, preferably includes a crankpin **43** for slidable engagement with the inner bore of the connecting-rod cluster (not shown). The first crankshaft member **42** may also include a counterweight element **44**. Preferably, the structural design of the crankpin **43**, and of the crank arm **45** which offsets it from the main drive shaft **42**, is such as to provide complete or substantially complete cantilevered support for the entire thrust delivered by the assembled engine.

The other or back-end sub-assembly is built around a back-end plate member **46**, which may also include a circumferentially extending machined portion **47** for close and tight-fitting engagement with the crankcase assembly. The end

plate 46 may include suitable bearing means 48 for providing main-bearing support for a second crankshaft member 49. In the form shown, this last sub-assembly is made to include the bearing 48 but not the crankshaft member 49, the latter being inserted upon final assembly, as will later be clear. The back-end sub-assembly may also include suitable auxiliary shafting 50 for driving the valve-timing mechanism. In the form shown, valve timing is effected through a reduction-gear train comprising a pinion 51 keyed to the shaft 50, a gear 52 supported on an idler shaft 53 and meshing with the pinion 51, a pinion 54 driven by the idler shaft 53, and a gear 55 driven by the pinion 54; the pinion may be formed with or locked to a single annular cam 56. The back-end sub-assembly may also carry cam followers 57 for cooperation with the cam 56 and suitable guide means 58 for supporting the cam followers 57 or other actuator means for the valve. The back-end sub-assembly is also shown to include a number of studs 59 to receive other auxiliary attachments for the engine, an annularly extending inlet-manifold system 60 with outlets 61 to the various cylinders, and suitable lubricating ducts for the main-bearing surfaces.

In the final assembly of an engine according to Fig. 4, the front-end sub-assembly is preferably first fitted to the cylinder-and-crankcase sub-assembly, as by introducing the crankpin 43 into the big-end cluster (not shown). The crankshaft member 49 is then fitted to that part of the crankpin which extends longitudinally beyond the back end of the cluster. In the form shown, this attachment is secured by means of a transverse pin or bolt means 62 carried by the crankshaft member 49 and fitting in a transverse groove which may be milled in the crankpin 43.

The front-end and crankcase sub-assemblies are then ready for fitting to the third or back-end sub-assembly. This fit may be accomplished by slidably introducing the main-bearing portion 63 of the crankshaft member 49 into the inner ring of the bearing 48 and in locking engagement with certain adapter portions of the auxiliary shaft 50. Final assembly may be completed by securing the end plates 38 and 46 to the crankcase as by employment of longitudinally extending bolts (not shown).

In order to maintain positive drive to the auxiliary shaft 50 means may be employed for locking shaft 50 to the crankshaft member 49. In the form shown, such connection is accomplished by providing the drive end of the shaft 50 with a projecting locating pin or stud portion 64 followed by a generally cylindrical portion 65 on which a flat 66 and a flat 67 have been milled. Preferably, the flats 66 and 67 are at different radial displacements from the axes of the auxiliary shaft 50. The crankshaft member 49 in turn is suitably formed with recesses and counterbored portions to receive parts 64 and 65 of the shaft 50, and it will be clear that the flats 66 and 67 will provide adequate locking. The fact that the flats 66 and 67 are at different displacements from the center of the shafts will clearly prevent any possibility of error or ambiguity in the timed operation of the cam as a result of errors in final assembly.

It will be appreciated that I have provided an improved structure for a radial engine, whereby simplification may be effected in the sub-assembly and in the final assembly of the principal parts. A number of parts have been eliminated. By fabricating the crankcase symmetrically about the plane of the cylinder axes, it will be clear that machining processes may be simplified. The arrangement is considered particularly useful from the view point of low-cost maintenance.

While I have described my invention in detail for the preferred form shown, it will be understood that modifications may be made within the scope of the claims which follow.

I claim:

1. In a crankshaft, a main shaft portion for principal power output, a crankpin portion including a cranking axis offset from the axis of said main shaft portion, valve-timing means, and a crank portion to engage said crankpin portion and for driving said valve-timing means, said crank portion including a hub journalled in a subassembly including said valve-timing means, and means within said hub and including axially slidable asymmetrical interlocking means for locking said crank portion and said valve-timing means against relative angular movement, said interlocking means being asymmetrically disposed about a normal section, whereby there may be a first subassembly including said valve-timing means and a second subassembly including said crankshaft and whereby said subassemblies may be readily assembled to each other without the possibility of error in the setting of said valve-timing means.

2. In a crankshaft, a power output end, a power take-off end, and an offset crankpin portion therebetween, valve-timing cam means, said power take-off end and said valve-timing cam means including cooperating axially slidable asymmetrical interlocking means, there being such asymmetry of said axially extending interlocking means that there may be but one relative angular position of engagement of said power take-off end and said valve-timing cam means, whereby said valve-timing cam means may be separately assembled and adjusted without the need for further adjustment after assembly with said crankshaft, and keying means engaging said power take-off end and said power-output end against relative angular movement about the crankpin axis, whereby said keying means may positively hold alignment of the main journalled axes of said power-output end and of said power take-off end, and whereby the load on said crankpin portion may be shared by separate end bearings for said power-output end and for said power take-off end.

3. In an engine of the character indicated, a crankcase subassembly including a crankcase open at both axial ends, a cylinder, a piston in said cylinder, and a connecting rod connected to said piston and free in said crankcase; a first end subassembly including a plate for one end of said crankcase, and a crankshaft member journalled in said plate; and a second end subassembly including a housing to cover the other end of said crankcase, a second crankshaft member, and valve-timing means connected to said crankshaft member and self-contained within the axial limits of said housing; one of said crankshaft members including a crankpin to cooperate with said connecting rod upon endwise assembly of one of said end subassemblies with said crankcase subassembly, and the other of said crankshaft members including means asymmetrical about the rotary axis of said crankshaft members and to be driven by said crankpin upon endwise assembly of the other of said end subassemblies

with the combined assembly of said one end subassembly with said crankcase subassembly.

4. In a radial engine of the character indicated, a crankcase subassembly, and two end-cover subassemblies, all said subassemblies being separately assemblable and being thereafter assemblable to each other upon end-wise sliding insertion so as to effectively close the crankcase, a split crankshaft including two parts separately journaled in and forming part of the two of said subassemblies, said two parts including interengaging means asymmetrical about the rotary axis of said crankshaft, one of said end-cover subassemblies including a housing and valve-timing means self-contained within the axial limits of said housing and connected to the crankshaft part in said one end-cover subassembly.

5. In a crankshaft, a main shaft portion for principal power output, a crankpin portion including a cranking axis offset from the axis of said main shaft portion, and a crank portion to engage said crankpin portion and including a valve-timing shaft portion and a hub, and asymmetrical locking means on said valve-timing shaft portion, said locking means including two flat surfaces parallel to the axis of said valve-timing shaft portion but at different radial distances therefrom, whereby upon assembly with further valve-timing means adapted to fit said valve-timing shaft portion there may be only one relative angular positioning of said interlocking parts.

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